in the previous conceptions, but does so by assuming with Darwin the intermediation of gemmules, a hypothesis to which objection has been made in the preceding pages. Brooks's theory also fails to admit the origin of variations through mechanical stresses, although he seeks for the origin of gemmules through the lack of equilibrium between the organization and its environment, which embraces that proposition in a less precise form. To Weismann we are indebted for the exposition of the separate origin and relative isolation of the germ-plasma, but no explanation of the origin and inheritance of new characters is offered. Ryder[2] has especially dwelt on the physiological division of labor seen in the tissues of the organism, and on the special function of the germ-plasma as the recipient of impressions through the processes of metabolism; but he does not go into greater detail.

ON VARIATION: WITH SPECIAL REFERENCE TO CERTAIN PALÆOZOIC GENERA.

BY PROF. JOSEPH F. JAMES.

THE question, "What are the limits of a species?" has been discussed for over two hundred years, and a satisfactory reply to it has not yet appeared. None of the numerous answers seem to meet all requirements. The conception of what a species really is has, too, been greatly modified since the publication of the "Origin of Species" by Darwin. It has been assumed by some of the more radical naturalists that species as entities are very rare, and that their boundaries are so indefinite that practically few exist. It is true that certain forms of animals and plants are distinct, or possess so few relatives that they seem to stand isolated. The Venus's Fly-trap among plants, and the Duck-bill among animals, seem to occupy positions which cut them off from all other plants or animals; but such cases are certainly exceptional. On the other hand, there are whole groups of

[2] AMERICAN NATURALIST, 1890, p. 85.

animals and plants where the lines between the various forms are so indefinite that they are practically absent. The testimony of both botanists and zoologists can be quoted in this regard. Lindley, though regarding species as "created by Nature herself, and remaining always the same" (Intro. to Botany, p. 307, 1832), yet states that "No absolute limits . . . . . exist, by which groups of plants can be circumscribed. They pass into each other by insensible gradations, and every group has apparently some species which assumes in part the structure of some other group" (Vegetable Kingdom, p. 30).

Among zoologists Milne-Edwards says: "When zoology is only studied in systematic works it is often supposed that each class, each family, each genus, present to us boundaries precisely defined, and that there can be no uncertainty as to the place to be assigned, in a natural classification, to every animal the organization of which is sufficiently known. But when we study this science from Nature herself we are soon convinced of the contrary, and we sometimes see the transitions from one plan of structure to an entirely different scheme of organization take place by degrees so completely shaded one into the other, that it becomes very difficult to trace the line of demarcation between the groups thus connected" (*Amer. Sci. Nat.*, Sept., 1840,—quoted by Lindl., Veg. Kingd., p. 31).

Nature recognizes but one class in her domain. That class is composed of individuals, and the individuals are her units. So, too, they are the units of man's classification, and for his own convenience he groups them into what he calls species; the species he arranges in genera, and the genera are collected in families or orders. Such a classification is necessarily more or less arbitrary, however natural it may be considered; and it is essentially artificial, inasmuch as no such grouping exists in Nature.

Among the individuals there is always a greater or less amount of variation. Sir Morell Mackenzie tells us that the muscles that form the human larynx are not arranged alike in any two individuals; and that differences in physiognomy are probably due to variations in arrangements of the muscles which move the skin of the face (*Pop. Sci. Monthly*, December, 1889). Though

the two Dromios as twins were as "like as two peas that grew in one pod," there are never two persons alike in all particulars. The fact of individual variation is especially insisted upon by Darwin, who, in fact, bases his theory of the origin of species upon their presence. In short, variation has been, and is, so generally acknowledged, that it seems almost superfluous to dwell upon it; but as it bears so strongly upon the facts to which I wish to call attention, I shall devote some space to its consideration.

It has been the fate of every naturalist who has given his time and attention to some special branch of natural science to become one of two things, or perhaps be one and then the other. He is either inclined to multiply species, or to suppress them and acknowledge only a few widely variable forms. Darwin has recorded his experience with stock breeders, and pigeon, duck, poultry and rabbit fanciers, and he states that all of these are fully convinced that each main breed is descended from a distinct species. He refers also to a treatise upon pears and apples, the author of which distinctly shows his disbelief that two varieties of apples could have originated from seeds produced by the same tree. He goes on to say: "The explanation, I think, is simple; from long continued study they are strongly impressed with the differences between the several races: and though they well know that each race varies slightly, for they win their prizes by selecting slight differences, yet they ignore all general arguments, and refuse to sum up in their minds slight differences accumulated during many successive generations."

The same idea is expressed later on where the remark is made: "When a young naturalist commences the study of a group of organisms quite unknown to him, he is at first much perplexed in determining what differences to consider as specific, and what as varietal; for he knows nothing of the amount and kind of variation to which the group is subject; and this shows, at least, how very generally there is some variation. But if he confines his attention to one class within one country he will soon make up his mind how to rank most of the doubtful forms. His general tendency will be to make many species, for he will become

impressed . . . . . with the amount of difference in the forms which he is continually studying; and he has little general knowledge of analogical variation in other groups and in other countries by which to correct his first impressions. As he extends the range of his observations he will meet with more cases of difficulty, for he will encounter a greater number of closely allied forms. But if his observation be widely extended he will in the end generally be able to make up his own mind; but he will succeed in this at the expense of admitting much variation,—and the truth of this admission will often be disputed by other naturalists. Where he comes to study allied forms brought from countries not now continuous, in which case he cannot hope to find intermediate links, he will be compelled to trust almost entirely to analogy, and his difficulties will rise to a climax."

It would be an impossibility, even were it desirable, to refer to all the recorded cases of variation among animals and plants. But it will be instructive to turn to some authorities in diffierent departments, and listen to what they have to say on this subject. Dr. Isaac Lea was well known as a describer of species, but he has put upon record his opinion of variation in the great genus Unio. It is well to note here that he attempted to divide the genus into different genera, but gave it up finally as impracticable and useless. In a paper read before the American Philosophical Society on November 2, 1827 (p. 260, as published in the "Transactions") he says:

"It has been doubtful with some concologists whether the species of the genus Unio are not the mere varieties of one species. To the naturalist, who has the opportunity of examining numerous specimens, the gradations are so interesting, and at the same time so perplexing, that he is lost in the maze of their changes, and he seeks almost in vain to draw a distinctive line between them; for even the tuberculated shells sometimes pass by almost insensible gradations into smooth ones."

In another paper read two years later (American Phil. Society, read March 6, 1829) he says: "The number of species [of Unio] adds greatly to the difficulty of distinguishing them, for they glide into each other so insensibly through their varieties

that the most experienced are often at fault and perplexed with the difficulty of placing them properly in the most approved system." He further remarks upon the variableness of the features upon which the species of Unio are characterized. For example, the teeth vary in the same species from one angle to another; they are thick in one specimen and thin in another; corrugated in some and in some smooth. The color varies in the same species, both in the nacre and in the epidermis. In most specimens of *Unio gibbosus* the nacre is dark purple, but it is also sometimes white. In *Unio verrucosus* it is generally dark chocolate, but it also varies to white. Mr. Lea says he has an Anodonta from the Ohio with the nacre of one valve white and the other salmon color. In certain species of *Unio clavus* the epidermis is beautifully rayed, but other specimens have no rays at all. In *Unio æsopus* the epidermis is sometimes glossy yellow, and sometimes dark brown. This is also the case with *Unio cylindricus*. *Unio alatus* again varies from a beautifully rayed green to nearly black and rayless. The tuberculations and undulations vary. Specimens of *Unio lacrymosus*, normally with numerous tubercles, are sometimes nearly smooth. *Unio plicatus* may have a few or have numerous folds, or even be nearly smooth. "The *Unio cornutus* is furnished with three or four protuberances or horns in a row, passing from the backs direct to the basal margin; the varieties of *cornutus* have these 'horns' more depressed and more frequent, and thus pass into varieties with a mere furrow without any distinct elevation, and these gradations are almost innumerable." The beak varies in the same species, as does also the general outline of the shell; as, for example, in *Unio luteolus*, which varies from oblong "pea-shaped" to a shorter form, with a broad anterior basal projection. The muscular impressions on the interior vary, as does also the ligament. In short, there is no character so constant that it can be made the certain characteristic of any one species. (See Ibid, pp. 407–415.)

Still later (in 1870) Mr. Lea returns to the subject of variation, and again calls attention to the fading of one species into another, and the difficulty of drawing lines of separation with any definiteness. (Synopsis of Unionidæ, p. 11.)

Other branches of zoology show similar variations. Dr. Carpenter, speaking of the Foraminifera, says in the Introduction (quoted by Wallace in "Natural Selection," pp. 162, 163) that an immense number of specimens of different species had passed under the observation of himself and Messrs. Williamson, Parker and Rupert Jones, and the result of the observation is said to be that "the range of variation is so great among the Foraminifera as to include not merely those differential characters which have been usually accounted *specific*, but also those upon which the greater part of the *genera*, and even in some instances those of its *orders*," are founded.

Mr. Wallace also refers (p. 165) to the studies of Bates upon butterflies, stating that "during eleven years he accumulated vast materials, and carefully studied the variation and distribution of insects. Yet he has shown that many species of Lepidoptora, which before offered no special difficulties, are in reality most inextricably combined in a tangled web of affinities, leading by such gradual steps from the slightest and least stable variations, to fixed races and well-marked species, that it is very often impossible to draw those sharp dividing lines which it is supposed that a careful study and full materials will always enable us to do."

Swainson, writing in 1835, in his volume "On the Geography and Classification of Animals," in speaking of the features which characterize species (p. 277), says that in some genera of the Dynastidæ the horn-like protuberances which distinguish the male sex vary in their length in almost every individual,—so that in some they are very prominent, while in others they are more iike short tubercles." And again he says: "The spines upon the different rock-shells (Murex), and on the coronated volutes (Cymbiola, Sev.), vary in like manner,—some specimens having acute and prominent spines,while others are nearly smooth."

In still another group of animals, the sponges, great confusion exists. Prof. Alexander Agassiz ("Three Cruises of the Blake," Vol. II., p.170) says that here "all our ordinary notions of individuality of colonies, or of species, are completely upset. It seems as if in the sponges we had a mass in which the different parts might be considered as organs capable in themselves of a

cestain amount of independence, yet subject to a general subordination, so that, according to Haeckel and Schmidt, we are dealing neither with individuals nor colonies in the ordinary sense of the words.

"As Schmidt well says: 'From the variability of all the characters, our idea of an organism as a limited or centralized individual disappears in the sponges, and in place of an individual, or a colony, we find an organic mass, differentiated into organs, while the body, which feeds itself and propagates, is neither an individual nor a colony.'"

We turn again for a few moments to the "Origin of Species" to show the recognized variability in a genus of plants. Darwin refers in considerable detail to the work of De Candolle upon the oaks of the whole world, pointing out his wealth of material, and the great care he took in the discrimination of species. He mentions that in this work De Candolle notes the many points of structure which vary, and "specifies above a dozen characters which may be found varying even on the same branch, sometimes according to age and development, sometimes without any assignable reason." Though not regarded as of specific value, they are yet such as often enter into specific descriptions. The rank of species is given in this case only to forms which differ in "characters never varying on the same tree, and never found connected by intermediate states." De Candolle remarks: "They are mistaken who repeat that the greater part of our species are clearly limited, and that doubtful species are in a feeble minority. This seems to be true so long as a genus was imperfectly known, and its species were founded upon a few specimens,—that is to say, were provisional. Just as we come to know them better, intermediate forms flow in, and doubts as to specific forms augment." He goes on to say, adds Darwin, "that it is the best-known species which present the greatest number of spontaneous varieties and sub-varieties. Thus *Quercus robur* has twenty-eight varieties, all of which excepting six are clustered round three sub-species." The forms connecting these are rare, and if they were to become extinct, "the three sub-species would hold exactly the same relation to each other as do the four or five

provisionally admitted species which closely surround the typical *Quercus robur.* Finally De Candolle admits that out of the three hundred species which will be enumerated in his Prodromus as belonging to the oak family, at least two-thirds are provisional species that are not known strictly to fulfill the definition above given of a true species."

Of our own botanists, the late Dr. Asa Gray was one of the most conservative. But he could not but recognize the wonderful variableness of certain genera, and he has left upon record his opinion of two of them (Proc. of the Amer. Academy, Vol. XVII., p. 163). He says: "Aster and Solidago in North America, like Hieracium in Europe, are among the larger and are doubtless the most intractible genera of the great order to which they belong. In these two genera, along with much uncertainty in the limitation of species as they occur in Nature, there is an added difficulty growing out of the fact that many of the earlier ones were founded upon cultivated plants, some of which had already been long in the gardens, where they have undergone such changes that it has not been easy, and in several cases not yet possible, to identify them with wild originals. Late flowering Compositæ, and Asters especially, are apt to alter their appearance under cultivation in European gardens. For some the season of growth is not long enough to assure normal and complete development, and upon many the difference in climate and exposure seems to tell in unusual measure upon the ramification, inflorescence and involucral braets, which afford principal and comparatively stable characters to the species as we find them in their native haunts. I am not very confident of the success of my prolonged endeavors to put these genera into proper order, and to fix the nomenclature of the older species; and in certain groups absolute and practical definition of the species by written characters or descriptions is beyond my powers. But no one has ever seen so many of the type specimens of the species as I have, nor given more time to the systematic study of these genera."

I have myself noticed the variation presented by two reputed species of rock cress (Cardamine), or, as it is usually called, Dentaria. Some years ago I collected at Lookout Mountain Ten-

nessee, *Cardamine laciniata* and *C. multifida*. In the first of these the segments of the leaves are frequently quite broad, sometimes half an inch, while in typical forms of the latter the segments are filiform. But I found there a series so perfectly graduated that the two extremes were connected by every intermediate form. In view of this graduated passage of one into the other, no one will dispute the justness of classing one as a variety of the other. The variety grows in dry soil, while the type form is more common in damp, shady places, and this difference of habitat may account for the differences in the leaves.

I have quoted freely thus far from writers on zoology and upon botany in order to show the general recognition of the fact of variation among the different classes of living forms. The references could be multiplied to an indefinite extent, for scarcely a student but has recognized the fact. The remarks already made must make it apparent to all that variation is the rule and not the exception. The question arises, noting the fact of variation among living classes, Are we not justified in extending the same idea to extinct groups? If variation is a fact in living forms, was it not likewise prevalent among those long since extinct? Nay, may we not go further and ask, Was it not more prevalent during the earlier periods of the earth's history than it is at present?

It is certainly a little remarkable that however much variation may be acknowledged in the living world, its presence among fossil forms has been largely overlooked. Whether it be the lack of extensive enough suites of specimens, or their very abundance, we can scarcely say. Most probably it is the former, combined, too, with the frequently fragmentary nature of the material. Palæontologists generally do not seem to have taken sufficiently into account the great variability of species; and with undue haste have rushed into print with new names that eventually add to the synonomy of an already overburdened science. Not that all are thus hasty, but too many are; and we can congratulate the cautious few who hesitate before attaching their names to species which soon appear only in the italicized form.

All geologists are aware that instances are not uncommon where species and even genera have been founded upon individ-

ual bones or teeth of animals which subsequent discoveries have shown to belong to a single species. It is also probable that among fossil plants species have been made from pieces of stems, or from leaves, which more abundant material will show to be portions of but one. Species are not unknown that have been made upon the single arm of a single starfish in an unperfect state of preservation; upon a fragment of a coral; the compressed or distorted body of a crinoid; the obscure internal cast of a bivalve; or the head, tail, or spine of a crustacean. So far has the passion for genus and species making been carried, that inorganic markings, "a single row of tracks," mud splashes, wave marks, and rill marks have been described: to say nothing of the scores of mollusk trails, worm trails, or worm burrows that have so long done duty as Algæ. We are glad to see, in some quarters at least, a reaction from this excessive species making, though in other quarters the name coining still goes on.

Perhaps one cause of the excessive multiplication of species in palæontology is the refusal for so many years to recognize the fact that the same species may have existed in two distinct areas, or throughout two distinct epochs. As among certain botanists and zoologists the presence of the same species in two widely separated countries was, and is, considered sufficient cause to make two species, so the occurrence of identically the same forms, as far as our specimens can tell us, in two geologic horizons, or in two distinct localities, is considered *prima facia* evidence that we are dealing with two distinct species. Even in one of the latest monographs published by the U. S. Geological Survey (Vol. XIV.) we observe an inorganic marking (as it appears to us), masquerading under the name of a sea-weed; and under a new name, too, because its brother rill mark existed some geological ages prior to its own oncoming formations. So, too, we see species of corals, of shells, of cephalopods, of crustaceans and others bearing distinct names because one lived in the Cincinnati, and another lived in the Trenton period; or because one lived in the ocean that covered New York, and the other that of Iowa.

We strongly suspect that a considerable amount of hesitation still exists among palæontologists against the acceptance of the idea of a former wide extension of species, both in time and in area. But it would appear that many are beginning to realize that variability must have existed in the past as well as at present; and that many species may have lived through several of the hard and fast periods into which geologists have divided geologic time. We have, for example, the testimony of Prof. James Hall, who (*American Geologist*, Feb., 1890, p. 122), in remarks made before the Geological Society of America, refers to the great variability of Spirifera and its allies. So, too, the large genus Orthis shows great variation in some of the species, as does also Endoceras. Mr. Matthew has recognized great variability in certain species of Paradoxides, and Mr. C. D. Wolcott has noted a remarkable series of variations in *Plenellus gilberti*, especially in the features of the head (Bulletin U. S. Geol. Sur., No. 30, pp. 173–180). These variations he considers to be the result of the retention, by some individuals, of certain embryonic features which are lost by the generality of the specimens after they attain a certain definite size.

There has developed, of late, a tendency to split some of the earlier and larger Palæozoic groups up into numerous genera, which are separated by few definite characters. It is especially prevalent among the lower orders, the corals and polyzoa, though the tendency is not confined here. Among many of the earlier forms it is extremely difficult to decide on any limitations to genera. If we take external characters as a guide, one set of writers say, "Those are of no value: use the internal structure." But when we turn to this, another set tell us, "Those features are utterly worthless: use the external form." Examination proves that certain species having a similar outward form have a different external structure; and certain others with quite diverse aspects have a like internal structure. The fact seems to be that in many of these early forms generic characters are not settled. The structure has not become stable enough to present definite features, and so many of the attempts to formulate definitions for genera are set at naught. Let us turn our attention now to some

of these groups, prefacing the examination by a reference to the mode and condition of preservation of one of them in particular, the corals.

The exposure of Lower Silurian rocks at Cincinnati is noted for the excellent preservation of its fossils and for their great abundance. Especially is it noted for the great number of individuals of brachiopods and corals. The rocks which now make up the formation were most likely deposited upon a ridge in the bottom of the ocean, previously formed by the contraction of the earth's crust. A warm current of water sweeping over this brought quantities of food, and enabled the animal forms to increase and multiply. Gradual growth, assisted, probably, by elevatory forces, must at times have brought the rocks up to or near the surface of the water, subsequent sinking allowing additional matter to be deposited. There seems little reason to doubt that these rocks were deposited in shallow water, and under conditions which brought them at times even above its surface.

As already stated, the corals are among the most abundant forms. They occur at certain localities literally in thousands, and where the shale has crumbled through weathering, they cover the ground so one can gather them up by the handful. Attention was first directed to these corals by a scientific man about 1870, and since then they have been the special study of a number of palæontologists.[1] First one and then another undertook their study, until now a rather thorough knowledge of the group is the result. At first the few described species were referred to the genus Chætetes. Later investigations caused them to be placed in the genus Monticulipora, and a special family was established for them, for which reason they have frequently been called the "Monticuliporoids." At first this single genus Monticulipora, like Chætetes, was enough. Then it was divided into five sub-genera, this classification being based largely on internal structure. Next we find it divided into twenty or more distinct genera, a host of species described, and the whole removed from the corals to the polyzoa. Since the first sub-division the work

[1] Consult the writings, especially, of U. P. James, Prof. H. A. Nicholson, G. R. Vine, and E. O. Ulrich.

has been continued, and new genera and species have been proposed, until the group has assumed such vast proportions, and contains such a mixture of forms, that it has become almost unmanageable. As an illustration of this fact it is observed that in a late work (North American Palæontology, by S. A. Miller), of the genera containing species that have been, and are still by some, referred to the Monticuliporoids, twelve are placed with the Cœlenterata, and nineteen with the Polyzoa.

The family as a whole is really a natural one, but it is also very diversified. It contains species which are massive, frondose, discoid or free, parasitic, and ramose. The division into the numerous genera has been based mainly upon internal structure. This, like the external form, is variable, and the one frequently bears no relation to the other; so that a massive form may have the interior of a ramose species, or a discoid be like a parasitic species. In reading the endeavors to divide the group up into families, genera, and species, we are struck by the enormous difficulty encountered. This cannot be better illustrated than by an extract from a lately published paper (Micropalæontology of Canada, Part II.), changing the language so as to make it less envolved, but not altering in the least the sense of the author. In this paper it is is said:

"The genus Diplotrypa, as now understood, embraces at least three small but well-marked groups of species, indicating relations to widely different families. The typical section bears a resemblance to true species of Monotrypa that may amount to affinity. Monotrypa comprises two very different sections, some being true Amplexipordæ with relations to Leptotrypa, while the typical section presents no very great affinity with any family.

"Batostoma, which has given no little trouble to place, is more intimately related to the typical sections of both Diplotrypa and Monotrypa than any of the others. The obvious relationship between the three groups suggests the erection of a new family, Diplotrypa being the type. By establishing this new family three troublesome genera are satisfactorily placed. But with this happy result comes another less fortunate, viz., are construction of Diplotrypa and Monotrypa. Thus the second section of Diplotrypa

approaches Prasopora, and ought perhaps to go with the Monticuliporidæ. This disposition, however, necessitates the adoption of one of two courses,—either a new genus would have be established, or the species would have to go under Prasopora."

Here we have an acknowledgment from one of the most industrious makers of new genera and species, of their great indefiniteness in this group, and of the difficulty of establishing limitations. It is exactly what should be expected. Believing in the evolution of many forms from one or a few primitive ones, we should be prepared to find in early geologic times genera and species beginning to differentiate. The Monticuliporoido first appear, as far as now known, in the chazy rocks of Canada, two species having been described in 1859, while a third has been lately recorded. In the Trenton period there is a sudden increase in the number of species, forty-four having received distinct names, while in the next period, that in which the Cincinnati rocks were deposited, no less than one hundred and eighteen names have been given to the different forms. It is not at all improbable that many of these are synonyms, but there can be no doubt about there being a great increase in the number of species during Cincinnati time. So,—too, there were introduced two new types of growth the massive and the frondescent, while there was at the same time a great increase in the the parasitic forms. In the Niagara period came a reduction in the number of species of true Monticulipora, and definite differentiation into genera began. The forms are nearly all ramose; the parasitic forms seem to have disappeared and true polyzoa, like Paleschara, to have taken their place. The Fistulipora-like forms assume predominance, and Monticulipora proper dies out. This is seen in the great increase of species referred to Callopora and Trematopora, both synonyms or very close allies of Fistulipora. This genus again is related to Chætetes, which in its turn is allied to the Favositidæ; while *this* family, represented by two species in the Lower Silurian, becomes wonderfully abundant in the Upper Silurian age.

In another group of corals, the Cyathophyllidæ, but three genera are found in rocks of Lower Silurian age, each containing only a few species. But in the rocks of a later age, notably the Niagara,

came an astonishing increase in numbers, and this continued up to Devonian time.

With the genus Orthoceras there is a condition of affairs approaching Monticulipora. Here is a straight, chambered shell, possessing constant and similar characters in most of the species; existing in extraordinary abundance at many different horizons; appearing first in the Calciferous, and increasing suddenly in numbers in the Trenton period; progressing, as it were, by leaps; occurring sparingly in one formation and abundantly in the next; and finally dying out altogether in the Permian. As many as 354 species have been named and described from America by authors, though the number of really good species will fall considerably below this.

In this genus, too, there have been two methods of procedure. In the one case a reduction of certain so-called genera to the rank of sub-genera or of synonyms; and in the other a great multiplication of genera. Professor Hall, for example, following Barrande, gives seven-teen synonyms for Orthoceras, and besides recognizes three sub-genera. Professor Hyatt, on the other hand, has restored many names discarded by Barrande and Hall, and has even increased their number. He recognizes eighteen distinct genera. These are separated upon the external markings of the shell, upon the coudition of the septa, the appearance of the siphon, and the form of the aperture. These straight forms may represent the embryonic stages and ancestral types of the Nautiloid and Ammonitic forms, which in later geologic times became the predominant types. It is not the purpose here to discuss the validity of the many genera adopted by Professor Hyatt, but it does not appear philosophical to establish genera upon embryonic characters, especially among early Palæozoic types. The period cannot be regarded but as a formative one; the structurual features of many classes had scarcely attained sufficient stability to be constant; individual variation must have been wider than at present; and with our known imperfection of material, to attempt to separate into species even, to say nothing of erecting into genera, many of the fossils from the older formations, is often a hazardous task. These re-

marks apply not to Orthoceras alone, but to Monticulipora, to Orthis, and to other large genera of early geologic time.

One other genus will be referred to here. This is Fenestella. Professor Hall has probably studied this group as thoroughly as any one in this country. In his report as State Geologist of New York for 1882, he discusses the different genera which have been at times proposed for Fenestelloid forms of polyzoa; and, after quoting the descriptions of thirteen of these, he remarks (p. 8) that "after an examination of hundreds of specimens, offering a wide range of variation, I am convinced that the genera mentioned above have only a sub-generic value, and should only be included in the comprehensive genus Fenestella." He then proceeds to show by a series of illustrations the failure of all the characters upon which the genera had been founded. He concludes no generic character can be drawn from the the celluliferous character of the dissepiments; that the anastomosing of the branches is too indefinite to be a valid character; that the number of ranges of all apertures is too inconstant, for often in this regard the features of several genera are found in one example; and, finally, that the presence of a ridge or keel upon the branches is in many cases not even a good specific character. He then formulates a generic description of Fenestella broad enough to include the various forms.

In a later publication (Report of the State Geologist of New York for 1884, Professor Hall returns to this subject, and gives short descriptions of seventeen sub-genera, recognizing the fact, however, that the boundaries of many of these are very indefinite, and that several may eventually have to be united under one. Fenestella is mainly an Upper Silurian genus, and it is evidently in the same formative condition as Monticulipora in the Lower Silurian.

Does it not seem probable, then, that the disappearance from a certain horizen of a genus previously abundant, is the result of the differentiation of characters? If, for example, the very abundant genus Monticulipora of the Cincinnati rocks is present in greatly diminished numbers in the Niagara period, but is represented there by numerous species of closely allied genera, it

PLATE XLII.

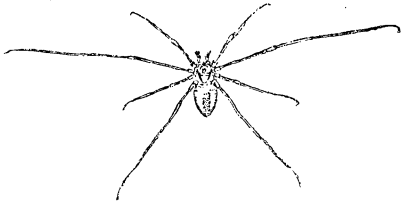

Fig. 1.

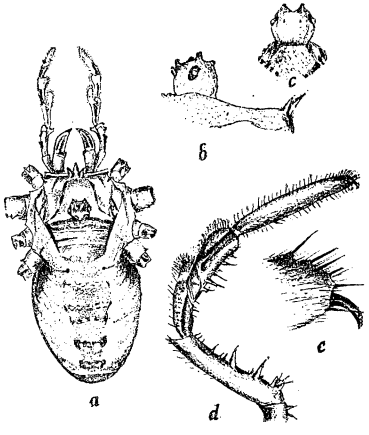

Fig. 2.

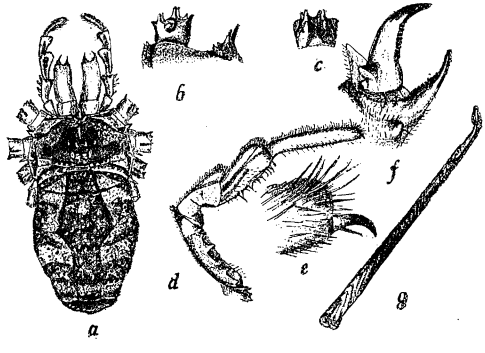

Fig. 3.

Otigolophus ohioensis and O. pictus.

would seem a proof that that the old and large genus was becoming extinct by the fixation of various structural types foreshadowed in it in a general way. May it not be for this reason, and not because of any sudden catastrophe, that the formerly abundant genus disappeared? In the three prominent genera of trilobites which characterize the three divisions of the Cambrian rocks, there is an example of the entire disappearance of one genus before the appearance of the next. Between the two earlier ones (Olenellus and Paradoxides) is an intermediate genus or sub-genus (Mesonacis) possessing features of both, while the presence of a connecting link (Olenoides) between the second and third genera (Paradoxides and Dikellocephalus) is also probable. Then the extinction of number one (Olenellus) will be in reality the birth of number two (Paradoxides); and the dying out of that form be the beginning of the life of number three (Dikellocephalus). Finally, may not this last genus find its representative in number four (Asaphus), which characterizes rocks still higher in the geologic column?

These are suggestions, not assertions. But at the same time we believe it to be really true that large genera of the earlier geologic periods contain in themselves the elements which, later on in the life of the world, become well-defined generic characters. Present only in a rudimentary form at one period, well-marked and distinctive characters appear at a later one.

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